

## INTERIM FINDINGS OF ACTS Ka-BAND PROPAGATION CAMPAIGN

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### INTRODUCTION

The ACTS Propagation campaign has entered the fifth year of **Ka-Band** data collection at seven sites in North America. The ACTS Satellite has two **propagation** beacons, one at 20.185 GHz with an EIRP of 22 dBW, the other at 27.5 GHz with an EIRP of 19 dBW. Specially designed ACTS Propagation Terminals have been installed at seven sites representative of rain regions in North America. Simultaneous measurement of rainfall and signal attenuation & scintillation provide a wealth of information on the long term statistics for designing **Ka-Band satellite communications** links. Through this effort, NASA is making a major contribution to growth of satellite communications services by providing timely data and models for performance prediction of Ka-Band satellite communications systems. This paper presents an up-to-date summary of the interim results of the ACTS propagation campaign.

### DATA COLLECTION

ACTS Propagation Terminals have been installed at the following locations, selected to be representative of rain regions in North America:

Fairbanks, Alaska, ITU Rain Region C  
Vancouver, British Columbia, ITU Rain Region B  
Ft Collins, Colorado, ITU Rain Region E  
Clarksburg, Maryland, ITU Rain Region K  
Las Cruces, New Mexico, Rain Region M  
Norman, Oklahoma, Rain Region M  
Tampa, Florida, Rain Region N.  
Each site measures and records

The ACTS Propagation Terminals provide simultaneous beacon receiver and radiometer output data at the two beacon frequencies, 20.185 and 27.5 GHz. Capacitive rain gauges were originally installed at all sites to provide instantaneous rain rate measurements; however they have proven unreliable and have been replaced by tipping bucket and/or optical rain gages, depending on the site. Rainfall is reported as one minute averaged rain rate. Data collection started in December 1993 at six of the seven sites, with the exception of the Clarksburg where data collection began in March 1994. Current plans call for data collection through December of 1998 to provide 34 station years of comprehensive Ka-Band attenuation and simultaneous rain-fall statistics for North America

## INTERIM RESULTS

So far 27 station-years of ACTS Ka Band Propagation data have been archived. Some of the findings have been reported by the investigators at NASA Propagation Experimenters meetings and ACTS Propagation Studies Workshops [1], [2], [3], and [4], covering: Commulative Fade Distributions, scintillation, antenna diversity gain, and attenuation due to rain water on the antenna.

The dominant free-space propagation factor at Ka-band is attenuation caused by rain. Figure 1 shows the commulative 4 year rain fade distribution measured at five of the seven sites for the ACTS beacons at 20 and 27 GHz. Data from the other two sites had not completed quality control at the writing of this paper, but should be available by November 1998. It is interesting to note that, 5 dB (7.5 dB) of link margin provides link availability of 99.3 to 99.9% depending on the site for most locations in North America at 20 GHz (27.5 GHz). These link margin requirements are only slightly larger than margins commonly used for Ku band satellite communications systems.

One should note that these results are based on experimental commulative fade distributions at the specific sites for a four year period spanning December 1993/November 1997. For system design, one should also allow for long term weather variations as well as dependence of weather on the exact location of the ground station. There are several models for predicting margin requirements for Ka-band link design. A detailed comparison of 20 station years of ACTS Ka-band data has been made with the most popular models [5]. Depending on the model used, the RMS error between measurement and prediction models varied from 39.16 to 66.91% (32.18 to 60.20%) at 22 (27 GHz) [5]. Work has started to build models based on detailed local climate for better prediction of rain attenuation at Ka-band, [6]. Thirty four station-years of ACTS data will be used to validate the new model. It is expected that this approach will provide a better prediction tool.

## CONCLUSIONS:

Interim findings of ACTS Ka-band propagation campaign indicate that link margins of 5 (7.5) dB provides link availability of 99.3 to 99.9 at 20 (27.5) GHz depending on the specific sites where ACTS Propagation data were collected in North America over the four year December 93-November 97. These link margin requirements are only slightly larger than margins commonly used for Ku band satellite communications systems which operate at higher availability. Applications compatible with these link availability statistics are most likely to use Ka-band. Based on these observations, NASA's propagation studies will be focusing on characterization of Ka-band attenuation in the 5-10 dB attenuation range. Current plans call for completion of five years of data collection through December 1998 and dissemination of the findings through ITUR.

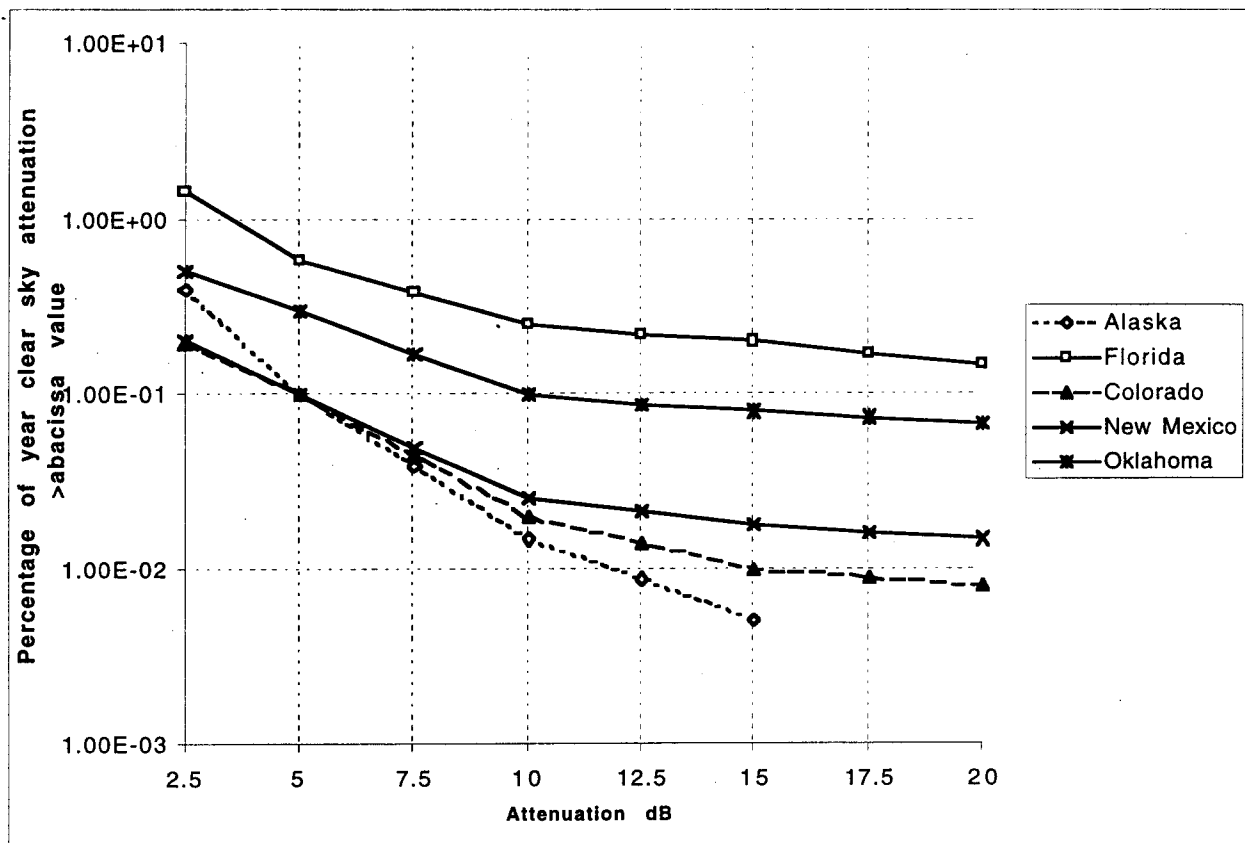


Figure 1a: Clear sky attenuation at 20.2 GHz averaged over four years of ACTS Propagation measurements, December 1993/November 1997 for five sites in North America

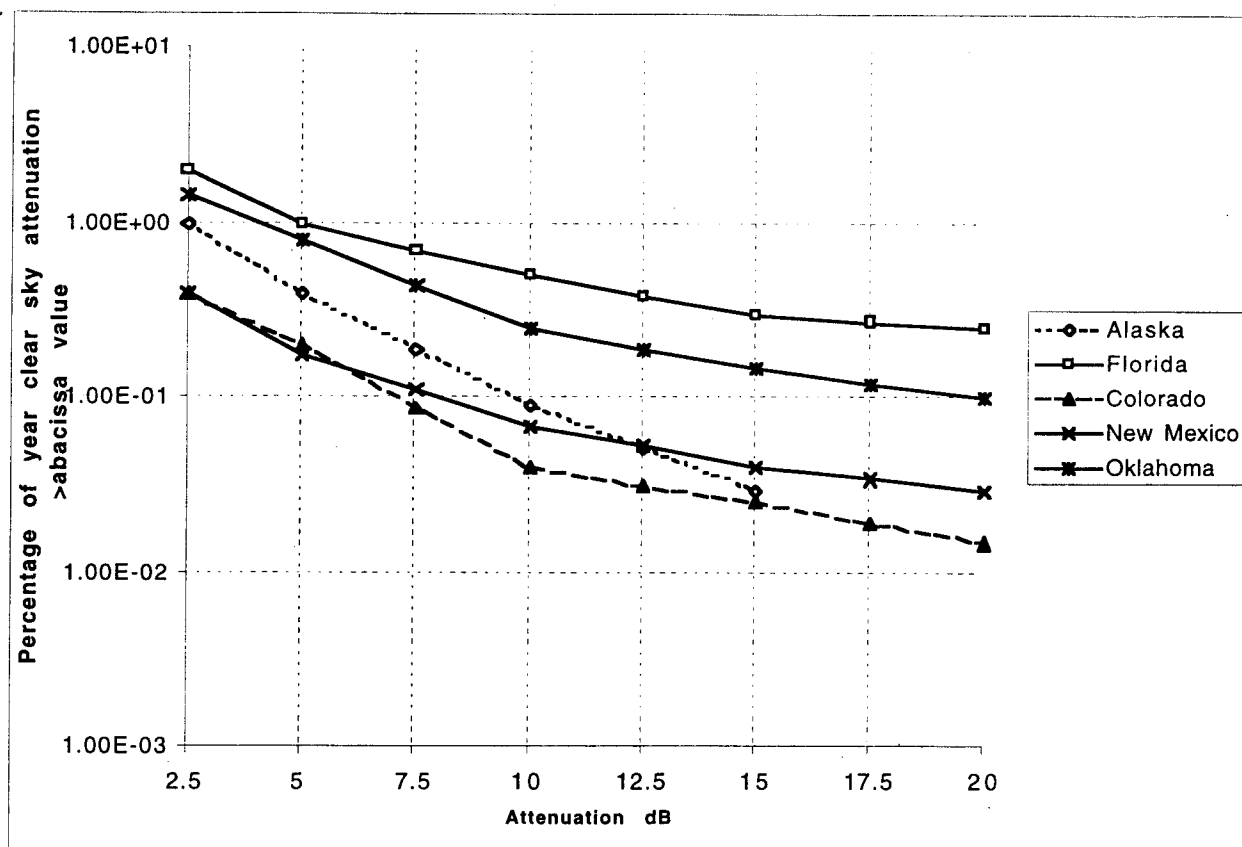


Figure 1.b: Clear sky attenuation at 27.5 GHz averaged over four years of ACTS Propagation measurements, December 1993/November 1997 for five sites in North America

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